3rd Science for the Environment Conference
Aarhus Denmark 1-2 October 2015

IMPROVEMENTS IN WATER QUALITY OF A DANISH ESTUARY FOLLOWING NUTRIENT REDUCTIONS

Peter A. Staehr1, Jeremy Testa2, Jacob Carstensen1

1) Aarhus University, Department of Bioscience, Frederiksborgvej, 399, DK-4000 Roskilde, Denmark, 2) University of Maryland, Center for Environmental Science, Chesapeake Biological Laboratory, Cambridge, Maryland, USA

ABSTRACT

We investigated estuarine ecosystem responses of a shallow temperate Danish estuary to large reductions in total phosphorus (TP) and total nitrogen (TN) loading from sewage treatment facilities and nonpoint sources. Our analysis utilized an extensive, long-term (1977-2013) monitoring dataset on water quality conditions (nutrient, oxygen, and chlorophyll concentrations) in combination with estimates of nutrient loading, freshwater inputs, and temperature. We used these monitoring datasets to compute monthly rates of net transport and biogeochemical transformation of inorganic nitrogen (DIN) and phosphorus (DIP) in two basins of the estuary using a physical salt- and water balance model for the years 1990-2006. We also estimated monthly rates of net ecosystem production from air-water gas exchange of dissolved oxygen (O2). Since 1990, nutrient loading was reduced by 58% for nitrogen and 80% for phosphorus, following improved sewage treatment and reduced diffuse releases, causing significant decreases in DIN (60%) and DIP (85%) concentrations, particularly in the inner part of the estuary. Despite these marked decreases, phytoplankton chlorophyll a (Chl) only declined marginally (10 % inner vs 13% outer), and improvements in water clarity were similarly minor (20 % inner vs 17% outer). Since 1990, net ecosystem production changed from net heterotrophy to near balance between primary production and respiration. These variables remained relatively constant during a period of large TP load declines in the early 1990s. Box model computations reveal that warm season net production of DIP remained elevated for several years after external loads were reduced associated with the continued release of P stored in sediments. Water temperature increased gradually from the 1990s through 2013, and seasonal cycles of Chl, net ecosystem metabolism, and net nutrient transformation appear to shift from April peaks to March peaks in the latter period (1997-2013). We conclude that nitrogen load reductions were the most effective control measures to improve water quality in this estuary. These analyses illustrate (1) the value of long-term monitoring data, (2) importance of sediment processes for the delayed responses in water quality, and (3) the potential role of altered seasonality as a mode of long-term change in estuarine ecosystems.